June 6, 1961 R. SLUIJTERS 2,986,775

SPINNERET ARRANGEMENT

Filed Oct. 22, 1959

Fig-1

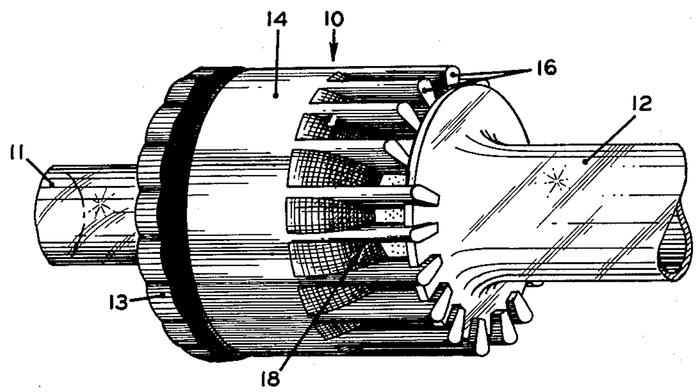


Fig-2

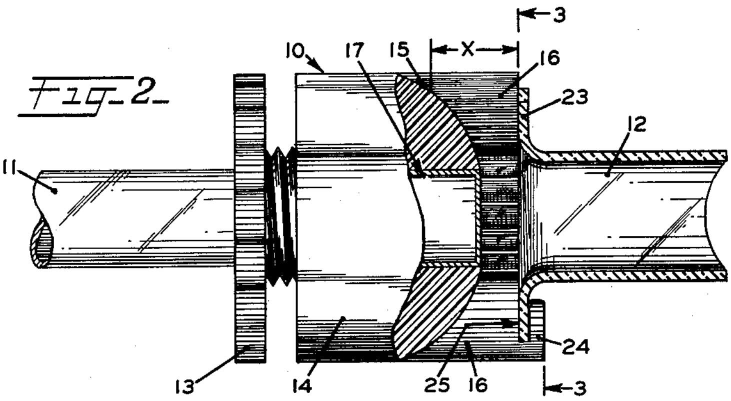
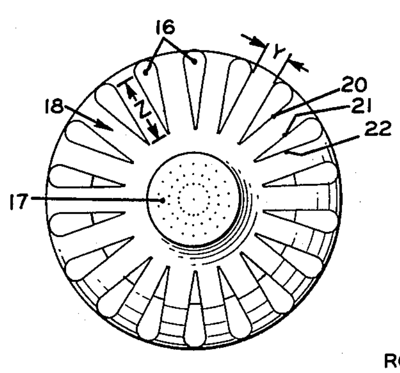


Fig-3



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SPINNERET ARRANGEMENT

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The present invention relates generally to the wet spinning of viscose rayon thread or yarn and more especially to the tube spinning of high tenacity yarn of particular use as cord in the production of vehicle tires.

It is now well known that yarn having higher tenacity than heretofore available may be produced by spinning viscose in the presence of chemicals which retard regeneration and coagulation. Use of these retardants or modifiers in most cases has necessitated conversion to the "tube spinning" system wherein the freshly extruded and relatively weaker filaments are passed through the critical initial regeneration stages with liquid traveling through a confined zone or tube.

A prerequisite to increased spinning speeds is elimination of turbulence and erratic flow of spinbath into and through the bundle of filaments at the point where the same are introduced into the spinning tube. More information on the problems encountered may be found in U.S. Patent No. 2,834,046, granted to F. Hesselink on May 13, 1958, and U.S. Patent No. 2,905,968, granted on September 29, 1959, to B. F. Walker et al., both of which are owned in common with the present application.

In most commercial applications of the aforesaid tube spinning system, the spinning tube is mounted in coaxial alignment with the spinneret face and is open at both ends, the thread and coagulant entrance end usually being funnel shaped and having a diameter greater than that of the outer circle of orifices in the spinneret, but less than that of the spinneret holder or assembly. It has been proposed, additionally, that a number of coagulant or spinning liquid flow passages be provided in the spinning tube near the entrance end thereof, as shown, for example, in the aforesaid Walker et al. patent. In this system the tube serves the purpose of protecting freshly formed and relatively soft threads from the transverse flow of the spinbath or spinning liquid, and the passages in the tube permit radial flow of spinbath into the system. Flow of spinbath through the tube may be caused by frictional engagement with traveling threads, or by a pressure drop which results in the converse, i.e., threads conveyed by liquid.

There are still disadvantages incidental to operation of the known tube spinning systems described above, although higher strength yarn is normally produced thereby. For example, the glass or other rigid material usually used in the manufacture of spinning tubes has been found to cause spinneret damage due to accidental engagement between these two members during spinning in or maintenance. Damaged spinnerets of course inherently produce disturbances in the spinning process. Moreover, the number of spinbath flow passages which can be formed in the tube is necessarily limited, since a large number of orifices would weaken the tube to such an extent that it could not be used. Further, it has been found that turbulence is inherently present in the liquid flowing through the perforated lateral walls of the spinning tube. This turbulent flow has a deleterious effect on the freshly extruded filaments. Additionally, these known systems have not permitted the desired rise in spinning speeds dictated by the competitive conditions which presently exist in the viscose yarn field, and accordingly have not pro-

duced an economic advantage of the magnitude anticipated.

Although the device disclosed and claimed in Walker et al. eliminates a considerable amount of turbulence in the spinning tube by the provision of oblong or elongated flow passages extending in the direction of spinning, the number of passages which can be provided is limited, as mentioned above. Consequently, the desired decrease in turbulence in the vicinity of the spinneret face is not usually attained. Moreover, this system does not provide the advantageous deep penetration of spinbath into the bundle of filaments near the spinneret.

An object of this invention, therefore, is to provide an apparatus not having the disadvantages of known systems described hereinabove.

An additional object of the present invention is to provide a spinneret assembly especially suitable for tube spinning which reduces considerably turbulence normally created near the spinneret face by flowing spinning liquid.

Another object of this invention is to provide a tube spinning apparatus which affords greater penetration of spinbath into a bundle of freshly extruded filaments but with no increase in damage to said filaments.

Still another object of the present invention is to provide a spinneret assembly which improves the rate of viscose coagulation and permits production of high tenacity yarns at higher spinning speeds.

A further object of this invention is to provide spinneret assemblies which require no point to point adjustment and which serve not only to support a spinning tube, but also to align the same with a spinneret.

Other objects and advantages will become apparent upon study of the accompanying drawings, wherein

FIGURE 1 is a perspective view of a preferred form of spinneret assembly, illustrating only those elements necessary to an understanding of this invention;

FIGURE 2 is an elevation view, partly in section, of the apparatus shown in FIGURE 1; and

FIGURE 3 is an end view, in elevation, of the spinneret assembly shown in FIGURES 1 and 2, taken substantially along the line 3—3 of FIGURE 2.

In accordance with this invention, the spinneret assembly is provided with partitions extending therefrom in the direction of spinning and defining a plurality of elongated passageways. The side walls of two adjacent partitions, which together define a single passageway, are flat and extend in parallel planes, whereas the two side walls of each single partition, which lie intermediate two adjacent passageways, should intersect near the spinneret to form an imaginary line extending substantially parallel to the spinning axis. From the foregoing, it can be seen that the cross-section of each partition is of generally "tear-drop" shape.

Attention is now directed to the drawings, wherein reference numeral **10** indicates generally a spinneret assembly such as described briefly hereinabove. In the wet spinning process to which this invention pertains, the spinneret assembly would be submerged in coagulating liquid or spinbath contained within a spinning tank, neither of which is shown. Viscose is supplied to the assembly through spinneret tube **11**, and the freshly extruded threads, as well as the coagulating liquid, pass outwardly from the assembly through spinning of flow tube **12**.

The spinneret assembly **10** consists of a male portion **13** and a female housing section **14**, these parts being screw threaded together in a known manner. The front or spinneret side **15** of housing **14**, in the preferred embodiment, is substantially spherical in shape, and has formed integral therewith a plurality of partitions **16** each of which extends outwardly of front side **15** in the direction of spinning and is supported therefrom in cantilever fashion. These partitions also extend radially inwardly of housing 14, as shown in FIGURES 2 and 3, from a point flush with the outer peripheral surface to a joint just outside the outer circle of orifices in spinneret 17.

As can be seen from the drawings, and as will be pointed out more specifically subsequently, each of the partitions 16 is elongated; consequently, the flow passageways 18 defined by adjacent pairs of partitions also are elongated. These partitions are provided with rounded inner and outer peripheral surfaces, however, to facilitate flow of spinbath through the passageways. The cooperating flat surfaces of adjacent partitions, as indicated at 20, 21 in Figure 3, should lie in planes which are parallel to an imaginary radial plane and accordingly extend parallel one to the other. On the other hand, the opposed flat surfaces on any one partition, as shown at 22 in Figure 3, should lie in a plane which intersects that of the complementary surface 21, in order to improve the flow of coagulant, as well as reduce the turbulence thereof. The end surfaces, or head ends, of the partitions 16 lie in a plane extending normal to the spinning axis, or normal to the center of flow tube 12, in order to permit flush mounting of the funnel shaped, or flanged, end 23 of the tube adjacent to spinneret 17.

Approximately one half, and preferably the lower half, of the partitions 16 are provided with extensions 24. These extensions are notched, as indicated at 25, and serve as a cradle or mounting bracket for the flanged end 23 of the spinning tube 12. The flanges and notches should be constructed in a manner to maintain coaxial alignment of the spinning tube axis with the center of the spinneret and yet permit quick detachment of the tube from the spinneret assembly merely by an upward movement of the former with respect to the latter. The flanged end 23 of the tube 12 closes off the flow passageways 18 between partitions 16, these passageways being otherwise bounded by spherical surface 15 and pairs of cooperating surfaces 20, 21.

The surface 15 was intentionally designed in spherical shape in order to decrease the volume or surface area of the passageways 18 in the direction of spinning, which produces an acceleration in spinbath flow as the same approaches the surface of spinneret 17. It can be seen, however, that the same effect could be obtained with a sloping flat surface, rather than one curved in the manner shown. If acceleration in spinbath flow is not desired, then the surface 15 should lie in a plane parallel to the aforesaid end surfaces, or head ends, of the partitions 16.

The filaments formed by extruding viscose from spinneret tube 11 through spinneret 17 are drawn off through spinning tube 12 and the coagulating bath by a driven roller, or rollers, not shown. Travel of these filaments through the spinning tube produces a movement of coagulating liquid contained within the tube, which of course draws in fresh liquid at the flanged end, as is known in this art. The special shape of the partitions 16, surface 15, and the flanged end 23 of the tube has been found to reduce considerably, if not eliminate entirely, the turbulent flow of liquid in the immediate vicinity of the spinneret. Consequently, the number of filament ruptures occurring during use of this apparatus is extremely small. Moreover, it appears that the coagulating liquid penetrates further toward the center of the filament bundle near the spinneret face and that more uniform regeneration is obtained at a faster rate of speed. This contributes substantially to the higher strength yarn produced by and higher spinning speeds obtainable with this apparatus.

It has been found that all of the advantages enumerated above cannot be obtained unless the partitions 16, and flow passageways 18, are carefully planned. Experiments have shown that the axial length X, lateral width Y, and radial height Z of the passageways bear a definite relationship one with respect to the other. The axial length X should be measured from the outer periphery of flanged end 23 to a point on the spherical surface 15 equidistant from the center axis of the spinneret assembly. The radial height Z should be confined to the flat surfaces only, and not include the curved inner and outer peripheries of the partitions.

The radial height Z of each passageway (or the height of the flat surfaces 20, 21, 22 on the partition) should be at least 1.5, and preferably 2, times the width Y (or circumferential distance between adjacent partitions). Moreover, length X, taken in the direction of spinning, should be large relative to the width Y, for example, at least 1.5 times this width. Preferably, the axial dimension of the partitions is at least 4 times the width of the flow passageways.

As pointed out above, the sides 21, 22 bounding a single partition 16 intersect at the inner periphery to form a line extending substantially parallel to the assembly axis. As a matter of practice, these lines should not extend exactly parallel to the axis, but should diverge slightly toward the spinning tube axis, in the direction of spinning, in order to facilitate molding of the assembly in one composite piece. Without such, it would be extremely difficult to remove the assembly at the end of a molding operation. Moreover, the intersection of corresponding surfaces 21, 22 of respective partitions 16 should occur outside the outer circle of spinneret orifices, although the exact distance radially outwardly of this circle is not critical. A large spacing at this point is not preferred, however, since this would require use of a large spinneret holder. On the other hand, an extremely close spacing also is not desirable since this results in placing of the partitions very close to the spinneret, which produces undesirable turbulence in spinbath flow at this critical point. It is preferred, therefore, that the intersection of corresponding surfaces 21, 22 occur at a point just outside the spinneret face.

The width Y of the flow passages may vary within wide limits. Although a narrow passage indeed reduces turbulence, the same presents the possibility of rapid clogging due to impurities in the spinbath liquid. On the other hand, passageways that are too wide do not satisfactorily dampen the turbulent flow. It has been found that the best results are obtained, under actual operating conditions, if the width of these passageways amounts to between 3 and 4 mm. Since the radial height Z preferably amounts to about 2 times the width, it will be seen that length of at least 6 mm. will operate quite well at this selected width. The axial length X, which as stated preferably amounts to about 4 times the width, therefore should be at least 12 mm. In connection with these dimensions, it is not advisable to design the flow passages so that the length X is much over 40 mm. Preferably, this axial length is not more than 25 mm.

The optimum number of flow passageways, or the number which produces the most satisfactory turbulent-free conditions, appears to be dependent on the width of the flow passageways and on the size of the space enclosed by the partitions. The most advantageous situation appears to exist when the relation between the width (Y, measured in mm.), the diameter of a circle through the intersecting planes of the individual partitions (d, also measured in mm.), and the number of passageways (n) is determined according to the formula:

$$Y = d \sin \frac{180^\circ}{n}$$

If construction of the spinneret assembly does not correspond to this formula, the beneficial results obtainable in accordance with this invention are only partly achieved.

Applying the formula, it can be determined that with an assembly having a spinneret diameter of about 20 mm., with the aforesaid lines formed by the intersecting planes situated just outside the spinneret face, and a flow passageway width of 3 mm., the optimum number of passageways should be 20 or 21, depending on the spacing of the imaginary intersecting planes outside the spinneret face. If it is desired that the flow passageways have a width of 4 mm., the number is determined to be 15 or 16.

As stated earlier, the gradual decrease in surface area of the flow passageways in the direction of spinning is intended to impose an acceleration on the spinbath liquid forced through these passageways during the spinning process. Acceleration at this point contributes to elimination of turbulence in the vicinity of the spinneret face. This decrease in surface area may best be obtained by suitably shaping the spinneret holder, either with the curved surface shown, or with a flat sloping surface which extends at an angle to the spinneret axis. The extent of surface diminishing should be selected for each particular radial and axial length of the passageways and the diameter of the space within the partitions, and depends as well on the shape of other radially extending bounding surfaces of the flow passageway.

In order to eliminate the necessity for periodic adjustment, it is preferred that the partitions **16** be immovably secured to the housing **14**, and one to the other. Additionally, it is advantageous if, during operation, they maintain a fixed position with respect to the spinning tube. Various constructions of course would produce this result. For example, the partitions could be constructed as a unitary structure separate from but insertable adjacent to or between the spinneret housing **14** and flanged end **23** of the spinning tube. It is preferred, however, to form these members as shown, whereupon the lower half thereof may also serve as means for positioning and supporting the spinning tube relative to the spinneret. This arrangement also protects the spinneret, and is reasonably easy to fabricate. The number of parts forming the assembly also is considerably reduced.

The spinning or flow tube **12** of course could be secured by various other means, such as screw or bayonet joints, but the arrangement shown has definite advantages, discussed supra. It is not necessary to provide all of the partitions **16** on the lower half of the housing **14** with extensions **24**, since a fewer number obivously would serve to support and align the spinning tube, as well as permit quick detachment from the spinneret assembly.

Inasmuch as other embodiments will become apparent to those skilled in this art upon study of the foregoing detailed disclosure, it is intended that the scope of the present invention be limited only to the extent set forth in the following claims.

What is claimed is:

1. A spinneret assembly comprising a housing, a multi-orificed spinneret secured within said housing for receiving a spinning solution, a plurality of elongated and circumferentially spaced partitions supported in cantilever fashion from and extending outwardly of said housing in a direction disposed radially outwardly from but generally parallel to the axis of said spinneret, each of said partitions having opposed flat surfaces which intersect in a line adjacent to but radially outwardly from the outer circle of orifices in said spinneret, cooperating flat surfaces on adjacent partitions being parallel and defining a flow passageway through which a spinning bath may be circulated, the cross sectional area between the passageway defining surfaces taken in planes parallel to the spinneret axis increasing in proportion to the distance away from said axis in order to accelerate the flow of spinning bath passing therethrough, a spinning tube coaxially aligned with said spinneret, and extensions on a plurality of said partitions, said extensions being notched to receive and quick-detachably secure said spinning tube in aligned position.

2. An assembly as set forth in claim 1 wherein said cooperating flat surfaces on adjacent partitions define a flow passage way having an axial length (X) at least 1.5 times the lateral distance (Y) between cooperating flat surfaces, as well as a radial height (Z) at least 1.5 times the lateral distance (Y).

3. An assembly as set forth in claim 2 wherein the axial length (X) of said flat surfaces is at least 4 times the lateral distance (Y) between cooperating flat surfaces on adjacent partitions and wherein the radial height (Z) of said flat surfaces is at least 2 times the aforesaid lateral distance (Y).

4. An assembly as set forth in claim 3 wherein the number (n) of said partitions is dependent both on the diameter (d) of an imaginary circle drawn through said imaginary intersecting lines and on the lateral distance (Y) between cooperating flat surfaces on adjacent partitions, and is determined by the formula:

$$Y=d \sin \frac{180°}{n}$$

5. An assembly as set forth in claim 4 wherein the lateral distance Y is between 3 and 4 mm.

6. An assembly as set forth in claim 5 wherein the axial length X is from 8 to 25 mm.

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